PIONEERING THE NHMFL

Memories of the First Years on the Occasion of the 10th Anniversary of the Dedication of the NHMFL

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Looking back, it seems completely natural that the magnet lab has become what it is today: the leading facility worldwide in providing unparalleled research opportunities to the international science community in the highest magnetic fields possible. When we started 13 years ago, a handful of enthusiastic people under the leadership of Jack Crow, we wanted to create the best laboratory in the world. We were thankful for this unique opportunity. We worked day and night to make our dreams and ideas become reality.

Building an entirely new laboratory requires a special set of people. They can best be described as pioneers. It requires courage to come to an unknown place, leave defined and safe working conditions behind, persuade spouse and children to abandon friends and established relationships, and confront an unknown educational, fiscal, contractual, and climatic environment. We were from different states and countries, and we felt like immigrants in this small and unknown town Tallahassee, which we wanted to put on the world map of research in magnetic fields.

There were enormous challenges ahead of us. We had to transform an abandoned administrative building into a facility in which highly sophisticated scientific instrumentation could be operated. We had to define the specifications of the main technical equipment, such as power supply and cooling circuit, and find the vendors that could reliably provide this cutting edge equipment and the needed infrastructure. We had to design building extensions for the very specific needs of the NMR/ICR program, the resistive magnets, and the hybrid magnet. We had to start a magnet development program to provide the basis for successful design and construction of a large variety of next generation magnets, far beyond what existed at that time. We had to build a new laboratory from scratch with a sophisticated

The team of the first hour: Neil Sullivan, Bob Schrieffer, Hans Schneider-Muntau, an unidentified representative of Marshall Contractors Inc., Larry Campbell, Dwight Rickel, Jack Crow, Don Parkin, Tim Cross, John Miller, Steve Van Sciver, Bill Moulton, Denis Markiewicz, and Jim Ferner.

The vacant building before it became the National High Magnetic Field Facility. Two extensions were added, the NMR/ICR wing to the left, and the user facility for resistive and hybrid magnets, housing 16 magnet stations. The 26 MW cooling towers and the 4000 m^3 reservoir for chilled cooling water are at the far end.

infrastructure under an enormous pressure of time and budget constraints, and most important, make it operational within four years.

The Chancellor of the Board of Regents at that time, Charlie Reed, had been decisive in obtaining the laboratory for Tallahassee. He persuaded governmental leaders to provide the necessary budget to outbid our competitor, the MIT. In addition, he had identified a building for the future magnet lab in the Innovation Park, an industrial park south of Tallahassee. It had originally been built for administrative and training purposes, but had never been used. We had to adapt it to its new function. We proposed to build additional, specially designed wings on both ends of the existing building to match the research requirements and to reduce interference between the magnets themselves and the building structure. We modified the building, removed several walls and floors to create high-bay areas, and added additional reinforcements to make the building hurricane safe. Space at the ground floor was reserved for vibration sensitive instruments, such as SEMs and TEMs. The chemical laboratories were set up in the 3rd floor because of the simplified installation of fume hoods. A conceptual design of the NMR wing was established in cooperation with scientists of the NMR community, assuming a future need for four major very-high-field magnets, and a series of smaller NMR magnets. We were concerned about their interactions and the impact of ferromagnetic materials near ultra-high resolution spectrometers up to 1 GHz. This is the reason why the building has four long arms in wooden construction extending out perpendicular to each other. We even thought about the acceptable distance to moving ferromagnetic objects, such as cars. One should not forget that 600 MHz was the highest spectrometer frequency commercially available at that time (1990), and nobody knew if a 1 GHz magnet was technically possible and even less its environmental requirements.

It was our ambition to create the potential for the generation of magnetic fields of the highest quality, in not only strength, but also concerning field stability and especially vibrations. The experience gained in Grenoble was very helpful and guided us in the layout of the cooling water circuit. The cooling pumps were put on vibration absorbers mounted on solid and heavy concrete blocks, which were isolated from the rest of the floor, which itself was isolated from the main building. This reduced the transmission of vibrations through the floor and ground. The cooling water pipes were suspended elastically from the ceiling to avoid vibration transmission through the building, and the elbows were arranged in such a way that vibration transmission within the pipes was damped as much as possible. The magnet housings were designed for a symmetrical feed of the cooling water to reduce any remaining vibrations even further. It was a great satisfaction when we made the first comparison of the vibration level of the magnets of the Francis Bitter lab at MIT with the NHMFL magnets. The set-up with an antivibration device at MIT showed the same vibration level as the NHMFL magnet without any antivibration device. Measurements of hitherto unknown sensitivity were made possible, confirming that we had created new research opportunities and set new standards.

In parallel with designing the building, we pursued the technical installations. The first task was the definition of the parameters, such as voltage, current, current ripple, power level, water pressure, water flow rate. The original plan of NSF requested a 45 T Hybrid magnet and a 20 MW power supply. First calculations indicated that 20 MW would not be sufficient for generating 45 T and that at least 24 MW would be required. The fact that the installed electrical power level determines the achievable magnetic field, and especially our ambition to create the best and strongest facility in the world, convinced Jack that it would be worthwhile to obtain the highest power within the available budget. In addition, it was our goal to improve the field quality of the resistive magnets to approach it as much as possible to that of superconducting magnets. A very low field ripple would open a new dimension for sensitive measurements, similar to ones done in superconducting magnets, but at much higher fields. In multiple discussions with different potential suppliers, power level, power module size, current stability and ripple, and overload capability were explored. We decided that, within our budget, the optimum compromise would be a power supply consisting of four units of 8.5 MW with an overload capability for the rectifiers of 100%, and for the transformers of up to 10 MW for one hour. We had thus succeeded in doubling the power level compared to the original NSF solicitation opening the possibility of generating magnetic fields with resistive magnets at levels that were reserved at that time to hybrid magnets only. It was our choice to adopt the same electrical and hydraulic parameters as those of the magnet laboratory in Grenoble for two reasons: they represent an optimum compromise between different requirements, and they opened the possibility of cooperation. We wanted to establish and maintain a strong cooperation with the second largest magnet laboratory so that magnets could

The foundation of the wing housing the user facility with the resistive and hybrid magnets had been designed for maximum stability and low vibrations. The casting of the 1 m thick slab took several days and nights. It was the largest amount of concrete ever poured in Northern Florida.

Jack Crow with our first "baby," a 64 T pulsed magnet, built in cooperation with K.U. Leuven and tested successfully at Eglin Air Force Base in 1992.

At the dedication, the speakers honored the achievements and confirmed that a world leading facility for research in magnetic fields had been successfully installed. The Governor of Florida, Lawton Chiles, at the dedication ceremony on October 1, 1994. From left to right: Congressman Pete Peterson, Lt. Governor Buddy MacKay, Vice President Al Gore, Senator Bob Graham, and Director of NSF, Neil Lane.

be built together and even swapped if necessary or in case of major problems. In fact, the very first magnet operated in Tallahassee was a magnet built together in Grenoble, and we had a successful and cost saving partnership arrangement later with the design and construction of the 20 T large bore magnet.

The greatest challenge, however, was the task of delivering the magnet systems NSF had charged us to build. The Seitz-Richardson report had defined a wide variety of magnets the new national facility should develop and eventually offer to the scientific user community. One of my first tasks was, therefore, to establish a program and vision for the future efforts and to head a department that should take care of the magnet science and technology activities. The program presented to NSF required an enormous progress in the generation of magnetic fields far beyond the start-of-the-art of that time (1990); from 20 T to 25 T for superconducting magnets, from 600 MHz to 1 GHz for NMR magnets, from 25 T to 35 T for resistive magnets, from 30 T to 45 T and 50 T for hybrid magnets, and from 50 T to 75 T in pulsed magnets. To this impressive list we added two new pulsed magnet systems enabled through the cooperation with the Los Alamos National Laboratory and the availability of a 600 MJ generator; a 60 T magnet with a flat top of 100 ms, and a 100 T system. The new generation of magnets we wanted to build covered an enormous range of very diverse technologies, materials, and design and construction approaches. New technologies and a precise understanding of the physics and mechanics of magnets had to be developed. We were fortunate to have recruited a sizeable group of outstanding engineers who were intrigued by the challenge of building magnets no one had ever built before.

This dynamic group, aided by the efforts of outstanding technicians, pioneered many new ideas and technologies. I mention just a few examples to illustrate some important innovations. The use of cable-in-conduit technology and superfluid helium for the hybrid magnet, the development of a new epoxy system and reinforcement scheme for the 900 MHz, the new computer codes that added a new dimension to analyze and optimize magnets, the sol gel insulation for HTS pancakes, and the invention of the Florida-Bitter magnet. An article in this newsletter next spring will expand on the numerous world records and achievements by MS&T that confirmed the courageous and far-sighted vision established in the beginning that enabled the NHMFL to become *the* leader in magnet technology worldwide.

In parallel to the creation of the facility, the technical infrastructure, and providing the first magnets, Jack Crow also pursued with vigor to establish the scientific credibility of the NHMFL. His efforts were crowned by winning Bob Schrieffer to join the team in April 1991, followed by many other renowned scientists. A future article will describe this equally exciting part of our

Editor's Note: Dr. Schneider-Muntau was Director of Magnet Science and Technology from 1992-1997 and served as Deputy Director of the NHMFL from 1992-2002. Prior to joining the NHMFL, he led the magnet development program at the Grenoble High Magnetic Field Laboratory for 20 years.